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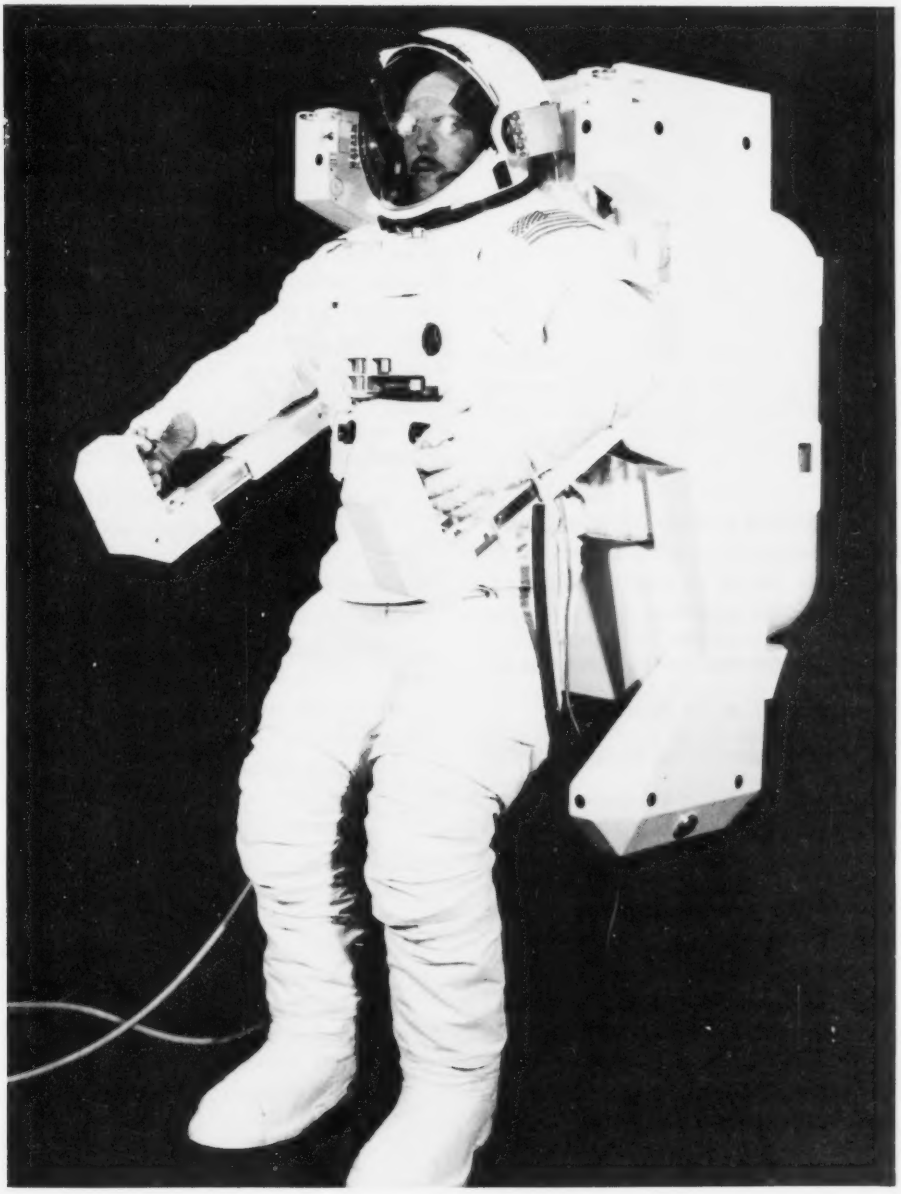

Cover

Outfitting for Orbit—Astronauts and engineers at the Johnson Space Center are evaluating a high fidelity mockup of a suit and backpack designed to allow Space Shuttle crew members to move around and work outside the spacecraft in orbit. Named the Manned Maneuvering Unit, it is a third generation flying machine, an improvement over units designed for Gemini and Skylab.

The suit could become a vital factor in the Space Shuttle schedule for 1980. According to officials at JSC, in-flight repair work on the orbiter's heat protection system might become necessary (see story on page 7).

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HEAO Sent Into Earth Orbit

The third and final High Energy Astronomy Observatory (HEAO) was launched at 1:28 a.m. on September 20 by the John F. Kennedy Space Center. The three satellites are expected to provide data on some of the most intriguing phenomena in the universe.

Using very sensitive equipment to detect x-rays, gamma rays and cosmic rays, the HEAO series of spacecraft allows scientists to study processes which occur inside such celestial bodies as stars, quasars, pulsars and black holes. High energy radiation can only be studied from space because it is absorbed or modified by the atmosphere.

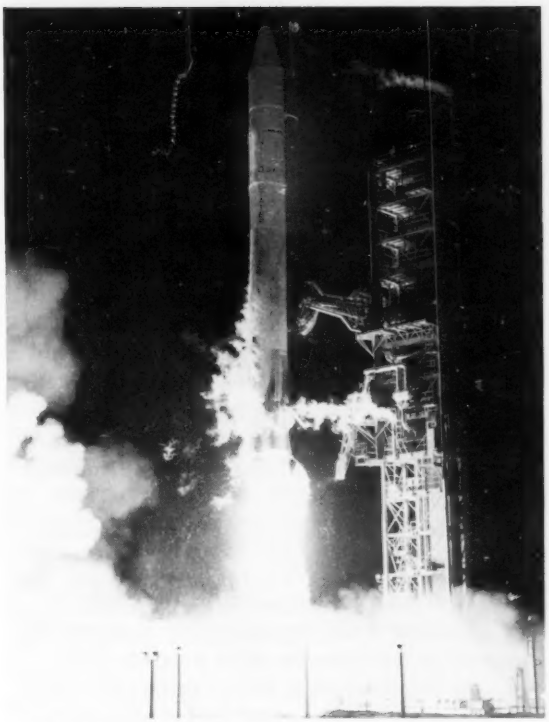
Earlier use of sounding rockets, high altitude balloons and most especially the smaller Uhuru satellite allowed scientists to discover some sources of x-rays. These tools were like the naked eye in visual astronomy. The larger and more sensitive HEAO spacecraft have done for high energy astronomy what the telescope did for visual astronomy.

The first HEAO was launched in August 1977 to perform a detailed survey of the skies, producing a map of x-ray sources. In its 17-month lifetime, HEAO–1 found more than 1200 new sources of x-rays and provided evidence for a universal hot gas theory that may account for a large portion of the universe's mass.

With an accurate map of celestial x-ray sources now in hand astronomers looked forward to the results of HEAO-2, launched in November of 1978. This second spacecraft, called the Einstein Observatory, contains the largest x-ray telescope ever built.

Designed to focus on precise points rather than to scan, the high resolution images from HEAO-2 tend to discredit the evidence for a universal hot gas. Instead, what appears as a hot gas cloud may actually be thousands of individual x-ray sources so distant from us that the effect is of an x-ray cloud. Such individual sources include a previously unknown quasar more than 10 billion light years away.

HEAO-3 contains two cosmic ray and one gamma ray experiments to study how high energy matter is created inside stars or other bodies. Like HEAO-1, the third spacecraft has a scanning mission with a design life of six months. All three spacecraft are in the 6000- to 7000-pound weight class and are carried to their orbits by Atlas-Centaur boosters. Future HEAO series satellites may be carried by the Space Shuttle.



Third and Last—The High Energy Astronomy Observatory-3 was successfully launched aboard an Atlas Centaur rocket from complex 36 at 1:28 A.M. EDT. on September 20, 1979.

Control of the orbiting HEAO–3 is being directed by the Marshall center in conjunction with flight control engineers from TRW, Inc., the prime contractor, operating from facilities at the Goddard Space Flight Center.

Special Shuttle Report

The special staff of individual consultants that was asked last May to assess the adequacy of the NASA Space Shuttle management system has submitted its report to the NASA Deputy Administrator, Dr. Alan M. Lovelace.

The special staff consisted of: Richard C. McCurdy, former NASA Associate Administrator for Organization and Management; Willis H. Shapley, former NASA Associate Deputy Administrator; Maj. Gen. James Abrahamson, F–16 Program Director, United States Air Force; A. Thomas Young, Deputy Director, NASA Ames Research Center, Mountain

View, Calif.; and John E. O'Brien, Assistant General Counsel for Procurement Matters, NASA Headquarters. Abraham Spinak, Associate Director, NASA Wallops Flight Center, Wallops Island, Va., was executive assistant.

Lovelace, in receiving the report and passing it on to Administrator Dr. Robert A. Frosch, said:

"This study was undertaken at my request in order to obtain an independent appraisal of the Shuttle management process which may have contributed to the sudden awareness of projected program cost increase which has been encountered during the past year. I want to commend the staff for their thoroughness and dedication during the four-month study. Their findings and conclusions constitute a very important input to our overall examination of Shuttle management."

The report contains eight major findings and conclusions excerpted as follows:

1. The original cost commitment for Shuttle development established an austere fiscal environment at the beginning of the program. This environment became more constraining under the annual budgets established in subsequent years.

In the formative stages of the Shuttle program, NASA officials were conscious of the need for an economical approach to space transportation. After much study and detailed analysis, NASA committed itself to a $5.15 billion development program (in constant fiscal year 1971 dollars), and agreed that the program could be accommodated within the NASA budget provided the latter was maintained at a constant level of $3.4 billion in 1971 buying power. This program was designed to achieve the first manned orbital flight in late 1978. The NASA commitment for the development program established a substantial management challenge to bring in a very difficult technical program within a limited budget. The resulting fiscal environment created demanding management challenges that shaped the Shuttle management approach.

2. The overall Shuttle management system has achieved a commendable level of accomplishment.

When reviewing a management system in response to a problem such as discussed above, the focus is necessarily on deficiencies. This is proper since these are areas requiring attention. It is important to note, however, that the personnel involved in the Shuttle Program have individually and collectively realized a commendable level of achievement on a large and very complex program. This is particularly noteworthy when consideration is given to the fiscal constraints which have been placed upon the program since its inception.

3. In the effort to live with funding limitations while still progressing acceptably toward completion, Shuttle management has generally set up work schedules that demanded more performance than could be delivered.

Many Shuttle Program officials believe that the result of the challenging call for work performance within the fiscal limitations has resulted in the most economical space transportation system program possible. There is no way to assess this view quantitatively. The approach did result in a portion of the

On Its Way Home—The Space Shuttle orbiter *Enterprise* as it rolled back to the vehicle assembly building (KSC) after its Pad 39 facilities test. This test helps clear the way for its sister ship *Columbia* to be launched on its first mission with space. The *Enterprise* was airlifted atop the Boeing 747 for its final flight to Plamdale, Calif. There, at the Rockwell International plant, it was stripped of its avionics and other salvageable items.

planned work being deferred each year as it was realized that the required funds exceeded those available. Moreover, as critical new work was recognized within a fiscal year and as technical problems developed, even more planned work had to be deferred. As a result, major planning adjustments were made continually which precluded the establishment of a stable baseline and caused inefficiencies within the program. For an example, subcontractor work has been accelerated and decelerated repeatedly in response to funding plan changes. This has occurred in critical areas such as tile manufacturing. The successive program changes and associated up and down expenditure rates have resulted in experienced contractor and subcontractor personnel being terminated. Recent and current aerospace industry demand for such personnel is such that experienced people do not remain available, resulting in the employment of inexperienced personnel at a cost to overall efficient performance. This constitutes a major cause for concern, especially for the production phase of the program. Additionally, cost increases have occurred associated with the deferred resolution of technical problems.

Rehearsal for the Main Event—Astronauts John W. Young, left, and Robert L. Crippen, crewmen for the first space transportation system (STS-1) mission, go over a checkoff list during simulations in the Johnson center's Shuttle mission simulator in the mission simulation and training facility. Young will be crew commander and Crippen, pilot, for the mission—Shuttle's initial orbital flight test.

4. There has been a lack of adequate long-range planning and timely status reporting. Emphasis has been on the current fiscal year, with only secondary attention to succeeding years and estimates to completion.

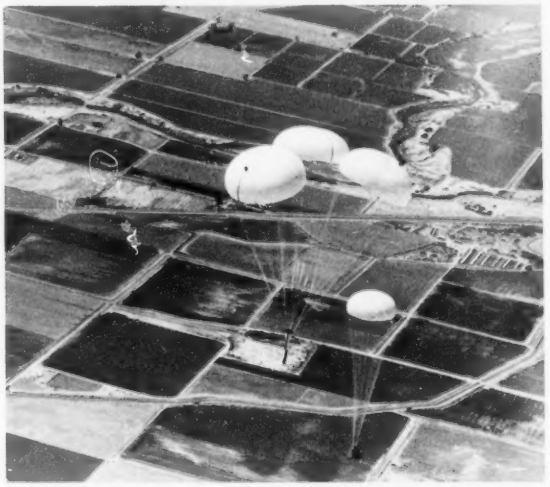
Long-range planning has not been performed to the extent required for a program as complex as the Shuttle. Effective long-range program planning has two basic elements: the first is a clear and timely understanding of what has been accomplished, the second is a reasonably accurate forecast of the work remaining. One of the most significant features of major portions of the Shuttle Program has been constant near-term replanning, the consequence of the issues outlined in finding Number 3 above. During this replanning, actual expenditures seem to have been accounted for and reported in a timely manner. However, the measurement of work associated with these expenditures, and estimation of the work to be done in the future has been weak. There are management tools which assist in this process, such as cost reporting integrated with work measurement systems. These have been implemented on some major Shuttle contracts, but only partially utilized on JSC contracts with Rockwell, a major portion of the Shuttle Program. While management tools assist in this process, they do not provide an automatic solution. In addition to these systems, responsible managers must make both near and far term estimates of work remaining with appropriate guidelines and good cost estimating tools. While much attention was given to these aspects of management for the near-term, there were planning problems which interfered with the process, i.e., budget guidelines have tended to reflect unrealistic cost and schedule objectives, near-term replanning has absorbed so much attention that long term impacts of deferred work have not been integrated into budgets, and overall status assessment has not been timely. In the absence of an effective status reporting system, the NASA agency-wide budget planning system, called the NASA Program Operating Plan, has been the only vehicle available for a comprehensive assessment of the total dollar requirements for certain parts of the Shuttle Program. Submissions to the plan occur in July and March of each fiscal year. In addition to the fact that the plan is not sufficient for pro-

gram control, there is an important gap from July to March when detailed updating information is not available. Discipline is needed now throughout the entire Shuttle program which will provide the means for identifying the overall program baseline and program status with quality projections of costs and realistic schedules. This must be introduced with sufficient understanding and management commitment to overcome the "culture" which exists due to the cumulative impact of the various constraints and pressures which have influenced the program management to date. Any management system introduced to accomplish this objective must necessarily depend in part on input from program contractors. It is important, however, that such a system be capable of independent assessment of program status including contractor performance.

5. The organization for the Shuttle Program appears to be functioning well from a technical standpoint, but is not functioning acceptably in the areas of schedule and budget. Strengthening of the organization at all levels is needed in these areas.

The original "lead center" organizational concept established at the beginning of the program envisioned a Space Shuttle Program Director (Level I) in the Office of the Space Transportation System Associate Administrator, a Space Shuttle program manager at Johnson Space Center (Level II—Integration), and separate Space Shuttle Project Offices at Johnson Space Center (orbiter), Marshall Space Flight Center (Space Shuttle main engine, solid rocket booster, external tank), and Kennedy Space Center (Checkout and Launch) known as Level III. The prime contractor support to the project offices is referred to as Level IV. With the passage of time three significant shifts in the original concept have occurred: (1) the Space Transportation System Associate Administrator has, through an ever increasing personal participation in the program activities, become the *de facto* Program Director; (2) the Space Transportation System Associate Administrator has required the Johnson Space Center, Marshall Space Flight Center, and Kennedy Space Center Directors to take a more direct and active role in program activities reporting directly to them; and (3) responsibility for overall program funding requirements shifted from the Level II Program Manager to Level I. The organization as it is now structured seems to be functioning reasonably well from a technical standpoint (although it should be noted that none of the management levels in Rockwell and NASA had a good grasp on the amount of open work and other complications associated with the shipment of Orbiter Vehicle 102 (Columbia) to Kennedy Space Center). With the changes that have taken place, the functioning of Level I has become even more crucial. During the course of the fact-finding, it became apparent that there was broad and detailed involvement of Level I on technical issues with lesser attention given to cost and schedule. Management attention should be focused on (1) achieving program balance between technical, schedule, and cost issues; (2) clarifying and strengthening organizational relationships at Levels I through IV; and (3) strengthening, where necessary, management control and information systems. Organizational elements dealing with resources and schedules should be strengthened at all levels so as to get in place a cost awareness discipline that is not unduly dependent on contractor input. Two-way communications must be improved so that lower level cost trends and budget estimates are fully understood and properly assimilated into program budgets and schedules.

6. Fixed Shuttle delivery schedules and initial operations require a new management approach.



Booster Recovery—To confirm recoverability of the two solid rocket boosters, the Marshall center conducted a series of tests at the National Parachute Test Range in California. Test versions of the boosters were dropped from aircraft to check the performance of the systems that will be used to return the big rockets to Earth. On a Shuttle mission, the boosters burn for about two minutes, providing more than 23 million kilograms thrust for launch. After burnout, they are lowered to the ocean by three main parachutes. Designed to float on the surface, they are ship-recovered and towed to port for refurbishing and reuse.

The Shuttle Program has utilized schedule as a reserve when APA and reductions of program content have been exhausted. Given fixed delivery schedules, the program now has a high degree of concurrency, and schedule is no longer available as a reserve. This requires a new management approach which recognizes the criticality of schedule as well as the previously emphasized technical aspects of the program. The importance of adequate budget, including an appropriate reserve is now obvious. Shuttle planning consistent with these new emphases must also recognize certain important factors. For example, work schedules and budgets must make realistic provision for modifications likely to be found necessary after the first few flights of orbiter Vehicle 102 (*Columbia*). Government and other prospective Shuttle users must recognize that the initial operational program will still contain developmental aspects. To assure successful initial operations, NASA must make and provide early, timely updates of realistic Shuttle performance and schedule commitments to the users. First priority must be given to successful completion of the development program.

7. The operational phase of the Space Shuttle Program takes on added significance and importance as the design, development, test and engineering phase comes to an end. Top NASA management should address the overall organization, external interfaces, institutional, and other management aspects of the operational phase. In particular, the NASA/Department of Defense interface needs immediate clarification to avoid misunderstandings which could have long term consequences.

The program management function for operations is performed at the Headquarters level. There are Center Space Transportation System operations offices at Johnson Space Center (technical integration of user payloads with the Shuttle), Marshall Space Flight Center (operations hardware—Space Shuttle main engine, solid rocket booster, external tank) and Kennedy Space Center (cargo processing, launch operations). There has been a great deal of valuable work done regarding user relationships, pricing policies, launch services agreements, interfaces with Spacelab and upper stages, etc. Although there appears to be a high degree of visibility and cooperation between the operations and Design, Development, Test and Engineering program offices, there are many aspects of the transition to the operational phase which remain to be worked out. Concerns have been expressed regarding the needs and plans of the Department of Defense user community as they impact NASA planning and budget preparations. Top NASA management should assure themselves that the current organizational alignments for Shuttle operations are appropriate and every effort should be made to maintain high level near-term understanding of Department of Defense planning to avoid problems in the operations phase.

8. The near-term potential for unanticipated technical problems, schedule slippage, and cost growth is high and appropriate reserves should be included in all aspects of program planning.

The special staff examined the Shuttle Program management from May to August 1979. At this point, the space transportation system faces significant development and operational challenges and uncertainties. It is clear that some aspects of a total management control and information system are in place and functioning well. However, there are significant deficiencies at this time as discussed in this document. There remains a significant potential for additional unanticipated problems and growth until these deficiencies are corrected and Shuttle plans and budgets are constructed on a more realistic basis with appropriate reserves.

Orbital Repair May Determine Shuttle Flight

The Space Shuttle will fly by mid-1980 but NASA scientists may decide that later crews must be able to inspect and repair the critical heat-shield tiles while in orbit. According to Kenneth S. Kleinknecht, the Johnson center shuttle vehicle manager, the in-flight repair work might be necessary unless the orbiter's heat protection system is proved virtually foolproof.

Two approaches to Space Shuttle orbiter heat-shield tile repair in orbit are under study at the Johnson Space Center. Although engineers are confident that the tiles will withstand the rigors of launch into space, the studies are aimed at repairing techniques and tools to be ready as a safeguard against flight delays.

Christopher C. Kraft, center director, said, "We have confidence in the orbiter thermal protection system and expect to fly the early orbital missions as planned. But at the same time we think it prudent to be prepared to make in-orbit tile repairs should the tile certification not come up to expectations. On the first flight, the aerodynamic pressures are only 70

percent of later flights so the inspection and repair might be more important for the second and third flights."

Thousands of heat-resistant blocks (tiles) cover the underpart and sides of the orbiter. In the event of damage to the tiles during launch, they may have to be patched before the orbiter could safely reenter the Earth's atmosphere, depending on the extent of damage.

"One lesson we learned from Skylab was that we could do repairs in orbit by going outside in spacesuits," said Space Shuttle engineer Reg Machell of the Johnson center. "Orbital inspection and repair is being considered as a kind of insurance against tile damage."

Machell's team is looking at two ideas for tile inspection and repair. The first concept calls for television cameras to feed a closed-circuit picture of tile condition to the crew in the cockpit before an astronaut wearing a spacesuit and life-support backpack could repair damaged tiles.

The second concept now being developed calls for an astronaut to wear a gas-jet maneuvering backpack as movements take place out and around the orbiter to inspect the tiles and make necessary repairs. The maneuvering backpack, officially named the Manned Maneuvering Unit, is an improved version of one test flown inside the Skylab orbital workshop during the second and third astronaut visits in 1973–74.

Both concepts call for the ability to detect damage measuring 26 square centimeters or more in the high-temperature reusable insulation that covers the orbiter's belly, the underside of the wings and the leading edge of the vertical stabilizer.

Repair kits under consideration include spray-on silicon carbide, a cure-in-place epoxy foam for replacing missing tiles, and a pre-cured ablator for bonding into areas that have sustained more serious damage.

Studies of designs for a tile repair kit are being made by General Electric Co., Reentry and Environmental Systems Division, Philadelphia; Martin-Marietta Aerospace, Denver Division; and McDonnell Douglas Corp., McDonnell Douglas Astronautics Company, Huntington Beach, Calif. Total cost of the three separate studies, which are to be completed in 10 weeks, is estimated at $250,000.

Along with inspection, the Johnson engineering team also is looking at tools, techniques and ancillary equipment needed for suited crewmen to carry out repairs while outside the spacecraft. Space center and aerospace industry engineers will study the concepts and techniques through the end of this year.

The first Space Shuttle orbital flight is expected to be launched in the spring or summer of 1980 from the Kennedy Space Center.

Tile Work at KSC—The installation of ceramic-coated tiles on the external surfaces of the Space Shuttle orbiter continues around-the-clock at the Kennedy center. Studies are underway on possible repairing of the heat-resistant blocks, if necessary, by Shuttle crewmen in orbit. In all, some 34,000 individual tiles make up the thermal protection system to absorb the intense heat of the orbiter's reenry.

First Shuttle Payload at KSC

Two experiments that will be part of the first payload to be carried into space by the Space Shuttle orbiter *Columbia*—the Shuttle Imaging Radar Antenna and the Ocean Color Experiment—have been delivered to Kennedy Space Center. The remaining five experiments are scheduled to arrive by the second week in October.

Columbia's first payload, called OSTA–1, is made up of seven experiments designed to carry out investigations for Earth resources applications. The payload, under the management of NASA's Office of Space and Terrestrial Applications will fly on the Space Shuttle's second orbital flight test scheduled for launch from KSC.

The firsit orbital Shuttle mission will carry instrumentation to evaluate its performance and will carry

a special package called the induced environment contamination monitor to measure the effects of the Shuttle on the space immediately around it. The monitor will be carried on all six orbital flight test missions.

The payload carried on the second shuttle flight is reusable. This will permit adjustment and modification of the payload instruments and other hardware to allow its use on subsequent flights at relatively low cost.

Five of the payload's seven experiments will be mounted on an orbital flight test pallet, a 3-meter long, U-shaped structure that fits inside the orbiter's large cargo bay. The other two experiments will be located in *Columbia*'s cabin.

Dr. Jim Ragusa, launch site support manager for the shuttle's first payload mission, said the pallet will be ready for mounting experiments this fall. Since its arrival last December, the pallet has been housed in KSC's operations and checkout building where technicians are outfitting it with systems for thermal control, electrical power and for commanding and acquiring data from the experiments.

Designed and assembled by the British Aerospace Corporation for the European Space Agency as part of the joint ESA/NASA Spacelab program, the pallet is nearly identical to experiment pallets to be used in Spacelab missions. This is the first of two pallet systems, with the next scheduled to carry physics and astronomy experiments on the fourth shuttle flight.

The first shuttle payload investigations are:

- The Shuttle imaging radar which uses large antennae to acquire data to evaluate a spaceborne imaging radar for geologic exploration, with particular emphasis on mineral exploration and fault mapping;
- The ocean color experiment which is designed to evaluate a passive ocean color sensing technique for mapping the concentration of chlorophyl-producing phytoplankton in the open ocean;
- The Shuttle multispectral infrared radiometer which will obtain radiometric data from a number of geologic test locations around the world in 10 spectral bands;
- Measurement of air pollution from satellites which will measure the variation in carbon monoxide—both natural and manmade—concentration levels in the atmosphere along the orbiter's flight path;
- The feature identification and location experiment which will provide a means for identifying, spectrally classifying, physically locating and tracking surface features or clouds;
- Night and day optical survey of thunderstorm and lightning which is the first attempt to look at lightning from space to develop lightning prediction techniques;
- Life science carry-on experiment which will determine the amount of moisture needed for plant/seeding growth in zero gravity and the prototype for an experiment to be flown aboard the Spacelab 1 mission.

Ragusa said after all preparations are completed, the pallet will be turned over to a NASA-industry team for about 4½ months of experiment integration. The payload will then be placed in a cargo integration test equipment stand, which simulates the orbiter's cargo bay, for testing interfaces between the pallet and the vehicle.

About six weeks before launch, the payload will be sealed inside the payload canister for transport to the orbiter processing facility and installation in *Columbia*.

Booster Motor shipped by Rail—A section of one of the huge solid rocket booster motors destined to help launch the Space Shuttle next year is hoisted aboard a flatcar in Utah for rail shipment to the Kennedy center. The motor was fully fueled at the Utah plant of its builder, the Thiokol Corp., before delivery and it traveled cross-country via the Union Pacific, Missouri Pacific, Southern Railway and Florida East Coast railroads. NASA's Marshall Space Flight Center controls the development and delivery of boosters and other components of the Shuttle's propulsion system.

U.S. Experiments to Ride Soviet Satellite

Thirteen United States experiments were launched in mid-September aboard an unmanned Soviet satellite in the Cosmos series, along with experiments from the Soviet Union and several other countries. All the experiments are designed to test the effects of weightlessness on physiological processes.

Forty scientists representing 18 U.S. universities and research organizations will participate in the Cosmos project, which is managed in the United States by the Ames Research Center.

The Vostok spacecraft, which will be recovered within the Soviet Union, is similar to those used on two previous Cosmos missions in 1975 and 1977, in which the U.S. also participated. Cosmos is inexpensive for the United States because the cost of the spacecraft and support activities is borne by the Soviet Union.

The major 1979 Cosmos payload consists of 38 white rats and 60 fertile Japanese quail eggs provided by the Soviets and shared among participating experimenters. Placed in orbit for about three weeks, the animals will be studied upon return for the effects of weighlessness on their physiology.

The mission will include the first attempt to breed mammals in space. The Soviets will conduct the breeding experiment, separating male and female rats until the second day of flight, when the divider between the cages will be removed. In addition, the quail eggs will begin incubation on the eighth day of flight. Resulting embryos will be studied on recovery, some being allowed to reach maturity.

Three of the U.S. experiments involve materials hand-carried to Moscow by U.S. scientists a week before launch. The scientists will return the recovered specimens to the Ames center.

Materials from the U.S. are carrot seeds and embryos, carrot slices inoculated with bacteria which can form tumors in plants, and film and plastic capable of detecting radiation encountered in space. Of particular importance are U.S. studies of changes in animal muscle fibers and of animal bone formation, turnover and strength. These are expected to provide insights into the reasons for calcium loss in the bones and a loss of muscle strength experienced by astronauts and cosmonauts during prolonged space flights.

After the flight, the animals must be recovered immediately, before they readapt to Earth gravity. As in previous Cosmos missions, the Soviet recovery team will move rapidly to the landing site and set up a mobile laboratory to perform dissections requiring immediate action. The remaining animals will be flown to Moscow, where some will be dissected after six days of readaptation to gravity, and the remainder after 25 days.

In Moscow, scientists will set up two groups of control animals identical to those going into space. One group will be left in cages and fed a normal diet. The other group, the synchronous control, will be housed in an identical spacecraft on the ground.

This group will be subjected to the same vibration and gravity forces of launch and reentry as the orbiting animals, then will experience any changes which occur in the orbiting craft as those changes are transmitted to Earth. This synchronous control will help ensure that differences between control and flight animals can be attributed to the experience of weightlessness.

The Ames center manages the U.S. portion of the Cosmos project for NASA's Office of Space Science. The NASA program manager is Robert Dunning. The project manager at Ames is Kenneth A. Souza and project scientist is Dr. Milton A. Heinrich.

Earth's Crustal Movements to be Studied

Seven laser satellite-tracking systems have been deployed by NASA in the United States and the Pacific Ocean as part of a continuing global effort to use space technology during the next decade to study the strain building up in the Earth's crust and to increase understanding of the causes of earthquakes.

Lasers have been installed on Tutuila Island, American Samoa; on Roi-Namur, Kwajalein Atoll in the Marshall Islands; and at Yaragadee in Western Australia. Four mobile lasers are established in the United States at sites near the Haystack Observatory, north of Boston, Mass.; the Owens Valley Radio Observatory, Calif.; NASA, Goldstone, Calif.; and Ft. Davis, Tex.

These lasers join an expanding international network of lasers and microwave facilities that will complement and extend conventional methods of measuring the Earth's crustal movements.

With lasers and microwave methods, which use signals from radio stars such as quasars, it is possible to measure movements of the Earth's crust and thereby analyze conditions under which pent-up strain may be released and cause earthquakes.

Satellite laser systems are in operation in France, Spain, Germany, Greece, Egypt, the Netherlands and

England. The United States operates, through the Smithsonian Astrophysical Observatory, laser systems in Arequipa, Peru; Natal, Brazil; and Orroral Valley in eastern Australia. With the addition of the new mobile NASA lasers, seven satellite tracking lasers will be in operation in the United States, including a system at the Goddard Space Flight Center and a laser operated by the Air Force in Florida.

Other laser systems, which use corner cube reflectors placed on the Moon by the United States and Russia, are in operation in Texas, Australia and West Germany.

The Earth's crust is believed to contain about a dozen large and almost rigid "plates" which are in constant motion and whose jagged edges continually grind against each other. It is believed that an earthquake occurs when the crustal rocks near the plate boundaries become locked together and are strained beyond their breaking point. The largest number of earthquakes around the globe occur at plate boundaries.

Historical geological data have allowed scientists to infer the average extent of movement of these huge plates over the past few million years. Some, like the Africa plate, are believed to be stationary or moving slowly at about one centimeter per year. The Nazca plate off the western coast of South America may be moving at 15 cm per year as it thrusts under the South American plate.

A long-term NASA project involving California's earthquake-prone San Andreas Fault even now is producing results for evaluating the use of satellite laser tracking for the measurement of strain build-up in the Earth's crust.

In California, the North American and Pacific plates are butted together at the San Andreas Fault. As the Pacific plates slide northward, portions of the fault appear to be locked.

The tracking of laser-reflecting satellites in known orbits permits scientists to pinpoint the location of their tracking systems to within three to five cm. The laser system flashes a narrow column of light pulses to the overflying satellite. Special reflectors on the satellite collect and return this light directly to its source. It is the precise measurement of the laser beam's roundtrip transmission time—at a speed of 300,000 kilometers a second—to the satellite and back that provides the essential information for locating the position of the ground unit.

Six satellites with laser corner cube reflectors are currently in use. The latest of these, the U.S. Laser Geodynamics Satellite, was designed specifically to be a reference point in space for ground lasers.

Corner cube reflectors were placed on the Moon by the Apollo 11, 14 and 15 astronauts. A French-built reflector was implanted by the Russian Luna spacecraft. Lunar laser systems at the McDonald Observatory (Texas), at Haleakala (Hawaii), Australia and in Wetzel (Germany) have been used to range to the Moon. Russia and Japan also are developing similar systems.

Within the United States, the U.S. Geological Survey, the National Oceanic and Atmospheric Administration, the National Science Foundation, the Defense Mapping Agency and NASA are participating in a joint program to apply this space technology to a better scientific understanding of the Earth's dynamic processes, including those related to earthquakes.

The NASA portion of this joint program is conducted through the crustal dynamics project at its Goddard center. The coordinated five-agency program is intended to support the national program authorized by the "Earthquake Hazard Reduction Act of 1977." Under this act, Congress initiated a broad research program whose goal is to reduce the hazards of earthquakes and develop, if possible, the capability to predict earthquakes and control them.

Saturn IB Welcomes Motorists to Alabama—Motorists driving southward from Nashville on Interstate 65 can see several miles in advance when they will enter Alabama. Towering 235 feet above the landscape is a Saturn IB rocket just south of the state line. The gleaming white vehicle has been mounted on a special concrete pad at the Alabama Welcome Center near the town of Ardmore. The rocket was dedicated officially on July 14 by Dr. W. R. Lucas, director of the Marshall Space Flight center. The vehicle was developed in the 1960s under Marshall center direction. The Saturn IB is being used by the State of Alabama to promote visitor attendance at the Alabama Space and Rocket Center, billed as the world's largest rocket and space exhibit. The facility is 51 kilometers from the Welcome Center and next door to the Marshall center.

Fighter Aircraft to Fly at Dryden

An F–14 fighter aircraft has been loaned by the Naval Air Systems Command to NASA's Dryden Flight Research Center where it will be flown in a joint NASA-USN program. It flies as part of NASA's in-flight research on current high-speed military aircraft. Dryden is currently operating two USAF F–15 fighters and Dryden pilots have flown the YF–17, the prototype of the new F/A–18 Navy multimission aircraft.

The F–14 program will include an in-flight assessment of a new control system concept developed by NASA.

Harriet Jacqueline Smith is the project manager for the F–14 research program at Dryden. As such, she is responsible for all management aspects of F–14 research operations.

Smith joined Dryden in 1954 as a research engineer specializing in flight mechanics and handling qualities. She has worked on various programs including the lifting body and wake vortex programs and has authored many technical reports concerning these subjects. Before her current assignment she was project engineer for the F–15, and responsible for flight planning and coordination.

Smith attended the University of California, Berkeley, Calif., where she received her A.B. in Physics. She later attended the University of Southern California at Los Angeles, where she earned her M.S. in Mechanical Engineering and an Engineering Degree in Aerospace.

Preliminary planning on the F–14 concept is currently underway to determine the potential to expand the program to include propulsion research, an investigation of the effects of external stores, and other areas of common Navy-NASA interest. Data from the program will be used to aid in the design of future high-speed aircraft.

Pilot and Project Manager—Harriet J. Smith, the first woman to be named as overall project manager for a specific flight research program, poses with project pilot Einar Enevoldsen before a Navy F-14 Tomcat fighter at Edwards AFB. Smith, an aeronautical engineer, has been with the Dryden center at Edwards since 1954. She will manage the flight test of a new control system concept on the swing-wing fighter plane.

Communications Satellite Experiments Cease

A historic U.S.-Canadian project to advance communications via satellite ended in October when the world's most powerful communications satellite relayed video and voice signals for the last time.

The Communications Technology Satellite has demonstrated that such powerful satellite systems can bring low-cost television to remote areas anywhere on Earth.

More than 160 United States experiments were conducted with the satellite during more than three years, ranging from business teleconferences—designed to save time and travel expenses for businessmen—to emergency use during a disastrous 1977 flood.

The highly instrumented portable ground terminal was transported some 100,000 kilometers in support operations for the satellite, which is in synchronous orbit some 36,000 km in space.

The technology satellite has been a joint project of NASA and the Canadian Department of Communication. NASA's Lewis Research Center was manager of the U.S. experiments, which ceased in June of this year. Canada designed and built the satellite which, for the first time, operated in the 12 to 14 gigahertz frequency band. The Lewis center also furnished the solar-powered traveling-wave transmitter which has 10 to 20 times the broadcast power of current communications satellites. NASA did the pre-flight environmental testing on the spacecraft and launched it from the NASA Kennedy Space Center on Jan. 17, 1976.

Canada continued transmissions through October when the satellite was officially decommissioned. The satellite's performance has almost doubled its two-year design lifetime and it has met all project objectives. A few months ago the radio signals weakened and engineers had difficulty determining the status of on-board systems.

Daniel J. Shramo, director of Space Systems and Technology at Lewis, in citing the satellite's accomplishments, said: "It's taught us that new frequency bands can be tapped successfully and that advanced technology such as embodied by the traveling-wave transmitter can bring startling advances in broadcast communications. We have demonstrated that low-cost Earth terminals may indeed be substituted for conventional big-dish antennas when sufficient signal-sending power is available from the spacecraft to provide clear, bright, two-way television between distant parts of the country and even between continents."

Among the satellite's more complex experiments was one in September 1978 involving transmissions between Buenos Aires, Argentina, and United Nations Headquarters in New York City.

Pictures and voices of conferees attending a Buenos Aires U.N. conference on technological cooperation among developing countries were fed via the satellite to the NASA portable ground terminal stationed just outside U.N. Headquarters. Remarks then were simultaneously translated into each of the five official U.N. languages and immediately relayed back to Buenos Aires via the satellite, to be picked up by earphones at the conference.

The satellite also carried high-speed transmissions of documents used to illustrate the Buenos Aires presentations. These were translated and beamed back to the Argentinian capital the following day. The experiment, hailed as a milestone, underscored both the feasibility and desirability of holding international conferences via satellite.

More commonly, the satellite processed "town meeting" exchanges between Congressional members and their constituents, exchanges between university lecture halls and student assemblies several states away and exchanges between teaching hospitals and medical assemblies separated by thousands of miles.

The satellite is expected to be the forerunner of commercial broadcasting satellites that will beam television and data directly into homes and business offices.

NASA Selects Investigations for 1980s Flights

Forty scientific investigations—33 from the U.S. and seven from four foreign nations—will be studied and developed for a series of Spacelab/Shuttle flights planned for the period between 1983 and 1985. Costs of the U.S. investigations are expected to total about $100 million over the next five-year period.

The foreign countries involved are Canada, France, Japan and Belgium. Each will be responsible for funding its own experiments and investigations. The investigations will be in the disciplines of astronomy, upper atmospheric physics, space plasma physics, solar physics and high energy astrophysics.

Forty principal investigators have been selected from 16 universities, four private organizations or companies and seven different government agencies. Over 250 coinvestigators are associated with the selected investigations.

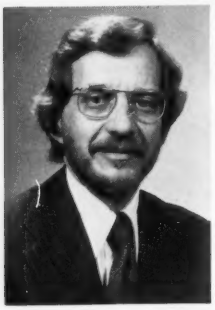
Spacelab will use the Space Shuttle as a carrier to and from orbit and remain attached to the orbiter throughout the flight. In space, it will serve as a platform for investigations in near-Earth orbit for about one week.

Almost 200 responses were received by NASA from the world scientific community in reply to an Announcement of Opportunity for Spacelab science investigations sent out last June.

With the advent of the Space Shuttle and the availability of standard space qualified hardware which can be placed in orbit, repaired, retrieved or replaced, NASA plans to exploit this capability and reduce the cost of such payloads while making space flight more accessible to a wider range of users.

It is intended that these investigations will be covered by new procedures which no longer require the investigator to adhere to the strict performance characteristics that had to be demonstrated prior to flight in former years. Now investigations must comply only with flight safety requirements and good engineering and management practices as provided in NASA policy guidelines. Investigations selected for development are expected to be assigned to a flight by NASA when it is determined that the investigators can meet their planned objective and a specific flight delivery date.

Dr. James Kramer Retires



Dr. James J. Kramer, NASA Associate Administrator for Aeronautics and Space Technology, NASA Headquarters, Washington, D.C. retired from federal government service on Sept. 30.

NASA Administrator Dr. Robert A. Frosch said, "Jim has been a stalwart of NASA and its predecessor agency, the National Advisory Committee for Aeronautics, for 28 years. He has kept NASA at the forefront of aeronautics and space technological advances for both civil and military applications. In the recent past, he has led our work in support of national energy goals. We will miss Jim, but I am delighted that he will continue to contribute to the aerospace sector of our economy."

Kramer has been named Manager of Strategic Planning for the Aircraft Engine Group of the General Electric Co., Cincinnati, effective Nov. 1.

He received the Arthur S. Flemming Award in 1969 for his significant contribution to new areas of research and project management. This award is presented each year to the 10 outstanding young men in government service.

Dr. Kramer was a Princeton Fellow in Public Affairs, 1973–1974, at the Woodrow Wilson School of Public and International Affairs of Princeton University. Prior to his current assignment, Kramer held the following positions in the Office of Aeronautics and Space Technology: Acting Associate Administrator, December 1976–October 1977; Acting Deputy Associate Administrator, July 1976–December 1976; Director, Aircraft Energy Efficiency Office, September 1975–July 1976; Director, Aerodynamics and Vehicle Systems Division, June 1974–September 1975. He was the Manager, JT3D/JT8D Refan Program Office, NASA Headquarters from 1971–1973.

From 1951 to 1971, Kramer was assigned to the NASA Lewis Research Center in Cleveland where he served as Manager of the Quiet Engine Project, Manager of the 260-inch Solid Rocket Project and aeronautical research scientist.

A native of Covington, Ky., Kramer graduated from Xavier University in Cincinnati, Ohio in 1949 with an A.B. in Mathematics and received an M.A. in 1951 from the same university. In 1975 he was awarded an honorary degree of Doctor of Laws for his outstanding accomplishments in various fields of engineering. More recently he was awarded NASA's Outstanding Leadership Medal.

Innovations Are Among Nation's Top 100

Three products from the Lewis Research Center and one invented at the Marshall Space Flight Center are included among Industrial Research/Development magazine's national list of the 100 most significant new technical innovations of the past year.

Winners of the magazine's IR–100 awards were honored at the Chicago Museum of Science and Industry on Sept. 20.

Copernicus' Seventh Birthday—Acting Goddard Director Robert E. Smylie (left) congratulates former Astronaut Fred W. Haise, right, of Grumman Aerospace Corporation, on the Aug. 21 seventh anniversary of the launch of the spacecraft "Copernicus," a model of which appears in the foreground. Grumman was prime contractor for the spacecraft. Haise was at Goddard for the anniversary party, held later that day at a Grumman facility. During its seven years of useful life, Copernicus (or Orbiting Astronomical Observatory-3) has been used by more than 160 investigators from the U.S. and 13 other foreign countries to observe over 450 unique objects. Haise, now Grumman's Vice President for Space Programs, was Lunar Module Pilot on Apollo 13, which flew April 11–17, 1970. The model shown here is itself a bit of history; it is the actual model which Grumman submitted with its original bid proposal to build the spacecraft.

One of the Lewis products named as an IR–100 award is the "Nasvytis Multiroller Traction Drive developed by Erwin V. Zaretsky, Stuart H. Loewenthal, Neil E. Anderson and Douglass A. Rohn of Lewis and Dr. Algirdas L. Nasvytis, president of Cleveland-based Transmission Research, Incorporated.

Other Lewis innovations selected by the blue ribbon panel of IR–100 judges are a Corrosion Resistant Ceramic Thermal Barrier Coating, developed by Stanley R. Levine, Philip E. Hodge and Robert A. Miller, and the REDOX Energy Storage System, developed by Lawrence H. Thaller.

The Nasvytis Multiroller Traction Drive is a fixed speed ratio transmission which acts as a speed increaser or decreaser.

It transmits power without gear teeth through traction forces on thin lubricant film. The Nasvytis drive differs from some 20 other commercially available speed traction drives in that it is designed specifically for highly efficient constant speed ratio service and can be engineered for various speed ranges and duty cycles. Compared with conventional gearing, the Nasvytis drive provides large reduction ratios in a single stage while conventional gears require a series of multiple gear meshes.

The Corrosion Resistant Ceramic Thermal Barrier Coating is designed to provide a protective coating between extremely high temperature erosive and corrosive gases and cooled metal parts. Its unique feature is its ability to withstand the corrosive conditions resulting from combustion gases contaminated with air and fuel impurities. It differs from other thermal coatings in that the ceramic is an alkaline earth silicate which offers superior durability in corrosive environments.

The third winning Lewis entry, the novel REDOX "fluid battery," is considered a major breakthrough in electrical energy storage and handling. The REDOX "battery" uses liquid electrolytes to store and deliver stored energy on demand, and can be recharged simply by reversing the direction of the current flow. It would replace lead-acid batteries conventionally used for remote area power storage and potentially could be used for economical, long life energy storage for conventional electric power utility systems.

The winner at Marshall was an energy-saving device invented by Marshall engineer Frank J. Nola, called a power factor controller. It senses the amount of power needed by an electric motor and automatically varies the power to provide only as much as the motor actually requires at any given time.

Calculations based on tests run on the Nola invention at the Marshall Center suggest that if all electric typewriters in the U.S., to cite one possible use, were equipped with Nola's Power Factor Controller, the savings in energy in that instance alone would be equal to that generated by between 2,000 and 3,000 barrels of oil per day.

A total of 26 firms throughout the U.S. have been licensed by NASA to produce and market the device, and about 30 more have applied for licensing.

Purpose of the awards, according to the magazine, is "to recognize innovators and organizations for out-

Astronaut Candidate sets Altitude Record—An unofficial sustained U.S. aviation altitude record for women (crew member) was set in July by Astronaut Candidate Kathryn Sullivan in a NASA WB-57F reconnaissance aircraft. The record altitude of 63,000 feet was reached during a four-hour flight out of Ellington AFB, Houston. Sullivan, in a high altitude pressure suit, operated color infrared cameras and multispectral scanning equipment for one and one-half hours over the Big Bend area of West Texas. The plane was piloted by Jim Korkowski of the NASA Airborne Instrumentation Research Program Pilots. Sullivan has a doctorate in geology and was selected in 1978 as one of 35 astronaut candidates training for the Space Shuttle program. She is destined to be a mission specialist and as such will be responsible for maintaining and operating similar equipment on Shuttle missions.

standing practical technical developments, and to identify significant technological advances of interest to scientists and engineers." The products were selected on the basis of their "importance, uniqueness and usefulness from a technological standpoint."

Chinese Delegation Indoctrinated in Landsat Capabilities

A seven-member delegation from the People's Republic of China met with NASA officials last Sept. 18, to discuss a memorandum of understanding for China's use of U.S. Landsat satellites. The delegation, during a month-long stay, conferred in Washington and elsewhere with users of Landsat data and visited ground station equipment manufacturers.

The delegation was led by Deputy Director Ji Bo, Committee on Space Science and Technology, Chinese Academy of Sciences, and included representatives from the Chinese Academy of Space Technology and the State Scientific and Technological Commission.

NASA made arrangements for the Chinese delegation to visit the Johnson Space Center; the NASA Earth Resources Laboratory at the National Space Technology Laboratories; and the Interior Department's EROS Data Center, Sioux Falls, S.D. The visitors were briefed thoroughly as to Landsat operations and potentials at all three installations.

The United States has two Landsat satellites orbiting the Earth at an altitude of 920 kilometers, scanning the surface in a systematic study of resources and environment. Three NASA tracking and data acquisition facilities are equipped to receive sensor data from the Landsat spacecraft.

The most important potential uses of the Landsat data identified so far relate to three of the major problems confronting the world today: energy supplies, food production and global environmental monitoring.

International interest in remote sensing of Earth resources is widespread and growing. Foreign-funded ground stations are now operating in Brazil, Italy, Canada (two facilities), Japan and Sweden. A ground station near Hyderabad, India, began test-training with Landsat 2 last month. Argentina and Australia each have a Landsat ground station under construction. Stations are planned by Chile, Zaire, Upper Volta, Kenya, Romania, Thailand and New Zealand.

The purchase of a Landsat ground station from U.S. industry is being undertaken under the U.S.-China Agreement on Cooperation in Science and Technology, signed Jan. 31, 1979, during the Washington visit of Chinese Vice Premier Deng Xiaoping.

Industrial Partners to Make Space Products

Guidelines have been set up for innovative joint ventures to make it easier for U.S. companies to use the environment of outer space for commercial manufacturing.

NASA is offering industry "equity partnership ventures" in the use of its Space Shuttle transportation system, and providing technical advice, data, equipment and facilities for commercial purposes. NASA Administrator Robert A. Frosch calls the action "necessary and proper to achieve the objective of national technical superiority through joint action with U.S. domestic concerns."

The guidelines are intended to facilitate the entry of American industry into an area traditionally left to the Federal government because of the high technology and high economic risks involved.

Space flight has been virtually untapped as a unique laboratory for materials processing. Ground-based research, however, as well as experiments in the Apollo, Skylab and Apollo-Soyuz flight programs and with sounding rockets, showed that materials in a liquid state behave much differently in the near weightlessness of space than on Earth, and that this behavior in space can be used to advantage in preparing a number of substances. For instance, there are no convection forces to make differing fluids segregate and no need for containers to hold materials as they are cast.

As a result of extensive materials-processing research already conducted on Earth, areas of potential commercial interest in space are: semiconductors—electronics, computers; infrared detectors—medicine, spacecraft; nuclear detectors—medicine, spacecraft; solid state lasers—communications, optics; microwave devices—communications, solar power; castings, alloys, composites and metal foams—metallurgy, machine tools; blood fractionation, purified hormones, enzymes, vaccines, products of live cells, cell culturing—medicine.

The joint venture program envisages a government-industry relationship in which the risk capital and technical expertise of industry can work in concert with the resource capabilities of NASA to develop and enhance U.S. commercial leadership in the field of materials processing.

To that end, NASA is providing a number of incentives to American industry, including:

- flight time on the Space Transportation System;
- technical advice, consultation, data, equipment and facilities;
- joint research and demonstration programs;
- proprietary information protection.

American companies desiring more information on NASA's joint venture program should write to: Dr. John Carruthers, Director, Materials Processing in Space, Code EM–7, NASA Headquarters, Washington, D.C. 20546.

NASA, Canada and France to test Rescue by Satellite

NASA, the Canadian Department of Communications and the French Centre National d'Etudes Spatiales have agreed to evaluate a satellite-aided search and rescue system. Plans call for a 15-month orbital demonstration and evaluation beginning in 1982. The trial system is expected to dramatically reduce rescue response time to sites of accidents to ships and planes by improving distress monitoring coverage, reducing detection time and providing more accurate initial location of vessels and aircraft in trouble.

Under the three-party agreement, Canada will provide spacecraft transponders and France will provide receiver/processors to be placed on U.S. National Oceanic and Atmospheric Administration polar-orbiting environmental satellites. The United States will modify the satellites, provide satellite antennas, integrate and launch the satellites and develop experimental emergency beacons for aircraft and ships.

The system will operate with the newly developed beacons and with existing experimental emergency locator transmitters and marine emergency position-indicating radio beacons. All three countries will provide ground stations and conduct demonstration and evaluation activities, including performance tests and simulated search and rescue demonstrations.

The satellites will "listen" on the 121.5 megahertz and 406 MHz emergency frequencies used by ships and aircraft. Traveling in orbits over the poles, one satellite can cover the entire globe every 12 hours. Within minutes after an initial alert is received, a fix that pinpoints the emergency site within 20 kilometers is produced by ground computers. The information is flashed to rescue coordination centers, notifying them that an emergency has occurred and identifying precisely the site of the problem.

Negotiations are under way among the parties to the satellite agreement and with the Soviet Ministry of Merchant Marine for possible cooperation with the Soviet Union. The Soviet Union is planning a similar system for its own spacecraft, with a view to establishing a system compatible with the U.S., French and Canadian one. The addition of the Soviet spacecraft would improve the system alert and response time.

If successful, the experimental project could eventually lead to the establishment of an international satellite-aided search and rescue system that would save lives of crash or marine emergency victims and significantly reduce the costs of prolonged search operations.

Wind Turbine Down for Repairs

Following completion of more than 600 hours of successful operation, the 200-kW wind turbine generator located at Culebra, Puerto Rico has been temporarily taken out of service to repair the two 18-meter aluminum rotor blades.

The blades were removed from the machine and returned to the Lewis Research Center for repairs, which will require 4 to 6 weeks to complete. The blades should be reinstalled and the machine placed back in operation by late November or December this year.

The 200-kW wind turbine was installed and placed in operation at Culebra in June 1978. Shortly after that, similar blades on the same type of machine located in Clayton, N.M. began to show signs of wear. Since the blades on the Culebra machine are of the same basic design as those on the Clayton one, project managers anticipated that similar problems would surface and that the blades would eventually need modification.

Repairs on the Clayton blades were completed in September 1978 and have since proved to be effective. Since installation, the Culebra wind turbine has supplied over 80,000 kilowatt hours of electric power for the Puerto Rican Water Resource Authority.

The third 200-kW wind turbine recently was installed on Block Island, R.I. A fourth machine of the same type is now being fabricated for NASA by Westinghouse Electric Corporation for installation in Hawaii during 1980.

The information that DoE and NASA have gained from the operation of these 200-kW size wind turbines is being used to design other larger machines that will produce much larger amounts of electric power. For example, a 2000-kW 60-m diameter wind turbine recently was installed at Boone, N.C.

Sophisticated Controls for Jet Engines

Testing of a fully computerized engine control system for jet aircraft of the future, a milestone in aircraft engine control technology, has been completed by the Lewis Research Center.

Developed through a joint NASA-Air Force project, the new multivariable control system promises a high degree of precision, responsiveness and repeatability in engine control, with the added benefits of greater engine life and reliability.

Heart of the control system is a digital computer that monitors many engine functions to ensure optimum performance under every anticipated operating condition. The computer continuously monitors these operating conditions and manipulates the engine's inputs in a far more precise manner than traditional cam-and-linkage hydromechanical control systems.

"The need for an improved engine control system became apparent as improvements in jet aircraft over the years increased the performance demands on engines," explained Bruce Lehtinen, project engineer at Lewis.

"To reach higher standards of responsiveness and efficiency, many more engine variables need to be controlled in addition to traditional inputs such as fuel flow," he said. "Multivariable controls are a must for engines intended for use in vertical take-off and landing (VTOL) aircraft of the future. Here as many as 10 to 15 engine operation variables must be controlled simultaneously."

Nicknamed a "smart carburetor," the Lewis developed multivariable control would monitor and control the engine's fuel flow, exhaust nozzle area, compressor bleed and fan and compressor variable vanes. In the process, the system would protect the engine from excessive pressures and temperatures and from rotor overspeeding.

Development of the control system began more than two and a half years ago, using space-age theoretical computer-aided design techniques. "The aim of the project was to develop and demonstrate a design procedure, not a piece of hardware," Lehtinen said.

For more than two years, the Lewis researchers and contractors carried out evaluations of the control system using a specially-designed engine simulator, prior to test runs on an actual F–100 power plant.

Potential applications of multivariable engine control systems in aircraft may be limitless in the years to come, the Lewis researchers believe.

"Well-integrated, automated procedures can be successfully used to design multivariable controls for coming generations of air-breathing engines," explains John R. Zeller, head of the Digital Control Systems Section at Lewis. "Such procedures can bring about more efficient and responsive engines in the future."

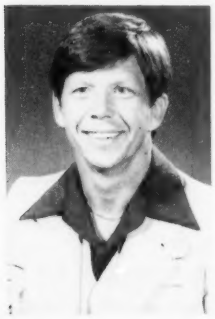
Multivariable control designs also have the potential of imparting added reliability and safety to engine control systems. The highly receptive "memory" of the system's digital computer can be programmed to store an engine control "model," which can be called upon to synthesize, or "recreate," critical factors of engine operation control in the event that a monitor/sensor should fail.

In addition, production versions of the system would be highly versatile and could be quickly

Scientific Six-Pack—Resourceful scientists at the Marshall Space Flight Center are using beer and soft drink cans as protective caps for gamma-ray and cosmic-ray detectors borne aloft by ballons. The aluminum cans, here adjusted by technician Demetra Chunn, make ideal covers for photomultiplier tubes operating at altitudes of up to 120,000 feet. According to one Marshall scientist, the inspiration for the cans came, after work, and over "a couple of beers".

adapted to the needs of different engines and unusual sets of flying conditions by "burning" a new chip into the computer, thereby reprogramming the unit. This feature promises to be a great advantage over the expensive, time-consuming process of redesign, manufacture and replacement of cams and linkages required in traditional engine control systems.

Crouch Receives NASA Fellowship



A Floyd L. Thompson Fellowship recently was awarded to Dr. Roger K. Crouch, an aerospace technologist in the electronic devices research branch, flight electronics division, at the Langley Research Center.

The Thompson Fellowship program was established in 1977 to encourage the development of research potential among Lewis staff members. It is named in memory of Dr. Floyd L. Thompson, who was center director from 1960–1968.

Crouch will spend one academic year at the Massachusetts Institute of Technology studying the effects of gravity on semiconductor crystal growth and materials processing in space.

He joined the Langley staff in June 1962. He earned a bachelor of science degree in physics in 1962 from Tennessee Technological University, a master of science degree in physics in 1968 and a doctor of philosophy degree in physics in 1971 from Virginia Polytechnic Institute and State University.

The author of more than 20 technical publications, Crouch is a member of the American Physical Society.

Fire-Fighting Module Proves Self

A portable, self-contained fire-fighting module developed by NASA was hurried from a demonstration site for use at a large warehouse fire Aug. 1. The module proved itself in actual use.

The fire broke out in a large chemical company's warehouse in Freeport, Tex., threatening surrounding facilities. Officials contacted the Fire School at Texas A&M University, College Station, where a module was being demonstrated. The module, which weighs less than 1,360 kg, was rushed to Freeport. It was pumping within minutes of arrival. During the next 13 hours it pumped an estimated million gallons of water at a rate of 2,000 gallons per minute from a moat near the warehouse. Most of the water streamed 80 feet to the roof where hatches were opened to let water run inside. The brick building held materials stored in 36 compartments.

In November, a multi-year demonstration program of the fire-fighting module will begin at St. Louis. The program will be coordinated by the Marshall Space Flight Center's Technology Utilization Office in cooperation with the Maritime Administration, Port Authority of St. Louis and the Coast Guard. Extensive tests, maneuvers and operations are planned at St. Louis, including public demonstrations in training and simulated fire situations. The Port Authority and a technical contractor will record data for evaluating the concept. This information will be made available to other port cities and interested parties.

Ames Man Wins Award

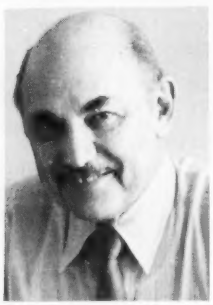
Charles E. Billings, of the Ames Research Center, recently won the Distinguished Service Award for "his pioneer work in designing, implementing, and operating the joint NASA/FAA Aviation Safety Reporting System." The award was givien by the Flight Safety Foundation, Aviation Week and Space Technology magazine.

The award said also: ". . . his medical expertise has permitted this unique safety intelligence system to place special emphasis on human factor elements in utilizing the records of airmen experience to the maximum extent possible in aviation safety incident avoidance."

Billings was nominated for the award by the Air Transport Association of America and the Air Line Pilots Association. He received the award Oct. 10 during the Flight Safety Foundation's 32nd International Air Safety Seminar in London.

In May, Billings also received the Presidential Safety Award from the Professional Air Traffic Controllers Organization "in acknowledgement of total and sustained dedication to the aviation community, for unwavering devotion to air safety and those who make the system the safest in the world; and specifically for unfailing support of and loyalty to the aviation reporting system."

Goddard Scientist Gets Memorial Award



The second annual COSPAR William Nordberg Memorial Award was presented in June to Dr. Morris Tepper of the Goddard Space Flight Center. The award was given for "most outstanding contribution to the development of international scientific cooperation in field of space research with regard to meteorology and earth surveys." Tepper is head of the special projects branch in the Laboratory for Atmospheric Sciences.

He is the first Goddard recipient of the award, established in 1976 by the Committee on Space Research of the Internation Council of Scientific Unions to honor the late director of Applications at Goddard. Nordberg died in mid-career after 17 years at Goddard pioneering the use of satellites for observation and measurement, and promoting the application of space science to the world-wide benefit of mankind.

The award notes that Dr. Tepper stimulated many well-known scientists to periodically analyze the status of space-based observing systems and to project their perspectives into the future. Additionally, he initiated symposia for the rapid exchange of information in the field of space meteorology and Earth surveys, and the assessment of the impact of space observations on various scientific and technological developments.

Tepper came to Goddard from NASA headquarters in 1978, where he was deputy director, earth observations program, and director of meteorology in the Office of Space and Terrestrial Applications. His career with NASA began almost 20 years ago upon joining the headquarters Staff to organize and direct the meteorological space program.

Two PAO Veterans Leave NASA

O.B. Lloyd, Jr., Headquarters public services chief, retired from NASA on Aug. 17. His departure via retirement marks the end of an era in Public Affairs which began in February 1961 when he joined the agency as Director of Public Affairs, succeeding Walt Bonney. He became director of public services in 1972.

In one way or another—advance man, protocol chief, trip coordinator—Lloyd has been closely allied with every NASA major and minor project since coming aboard. His travels for NASA have literally taken him around the world. His new address is Vandemere, NC 28587. Arrival of Lloyd and his family increases Vandemere's population to 402.

Old Public Affairs hands will recall that Lloyd is a native of Freeport, Ill., who grew up in Ponca City, Okla. After stints at the University of the South, Sewanee, Tenn., and the University of Missouri, he moved on to earn his degree at Northwestern's Medill School of Journalism. He has been in the trade one way or another ever since and was UPI bureau manager in Austin when Lyndon B. Johnson brought him to Washington in 1959 as staff assistant. Previously he had been in the news business in Chicago, Wichita Falls, Kansas City, Miami, San Diego, Houston and Dallas. Perhaps the biggest story (in his news career) was the Texas City ship explosion disaster in 1947.

Lloyd received NASA's Exceptional Service Medal in 1969.

Joe McRoberts, a NASA public affairs man for 17 years at headquarters and at the Goddard Space Flight Center, took the "early out" option, leaving NASA headquarters in September.

McRoberts joined NASA in 1962 when Paul Haney was in charge of the newsroom and Bill Lloyd was news director. His first project was Tiros–5. After that, the NASA pace became hectic in the extreme, with one launch following another—Telstar, Relay, Syncom,

and other early communications satellites—and McRoberts was in the catbird seat on all of them.

Later he became the Public Affairs officer for the Applications Office and then for the Office of Space Science. One way or another, McRoberts was involved in most of the NASA launches throughout the 1960s.

His next-to-last stint at Headquarters was with the Applications Office, after which (in 1973) he transferred to the Goddard Space Flight Center public affairs office. Recently he returned to Headquarters for six weeks to substitute for the ailing Nick Panagakos as public affairs officer for the Office of Space Science. In the job, he handled most of the Voyager 2 activities and was deputy for Panagakos during the Pioneer Saturn events.

McRoberts made some farewell remarks about NASA, to wit: "NASA is a very good place to work. It's important, exciting, demanding and highly recommended to those interested in working in public affairs. NASA accomplishments—the breaking of Earth's cocoon—will long be remembered when most people and events of this era are long forgotten."

. . . And a New Editor Joins the PAO

Keith W. McBee has been special assistant and speech writer for NASA management since 1975.

Formerly he was a special assistant in the Office of the Secretary of Transportation. His job involved civil aviation security and anti-skyjack programs. Before that, he was an American Broadcasting Company news correspondent. McBee covered Gemini and Apollo missions at the Cape, in Houston and downrange.

A native of Maryland, he attended the Johns Hopkins University and was an Army Air Force flight engineer in World War II.

Adm. Clark Dies at 73

Memorial services for retired Rear Admiral John E. Clark, immediate past deputy director of the Jet Propulsion Laboratory, were held in Pasadena, Calif., in October. Admiral Clark, 73, died in Pasadena after a long illness. He became deputy director of JPL in 1968, after serving as commandant of the 12th Naval District in San Francisco and commander of the Pacific Missile Range at Point Mugu. Clark was a graduate of the U.S. Naval Academy and served in World War II.

Contractor News

Convair Division of the General Dynamics Corp. has been awarded two contracts totaling almost $6 million by the Lewis center for Atlas and Centaur launch vehicle program support activities. Work on the cost-plus-fixed-fee contracts will be performed at the contractor's plant in San Deigo and at the Eastern Test Range in Florida. Over the next 18 months, the Atlas/Centaur launch vehicle is scheduled to launch HEAO–C, a Fleet Satellite Communications Spacecraft, and four Intelsat IV communications spacecraft.

The American Satellite Corp. has received a contract from the Marshall center for the operation of a portion of the administrative communications network. The contract covers some 36 long circuits used in the facsimile network as well as future requirements for high speed data and video lines. The corporation also is planning to construct an Earth station at the Marshall center.

Computer Sciences Corporation of Falls Church, Va., has been awarded a contract modification for technical services in support of NASA and other authorized Federal and state agencies at NSTL. The contractor will provide all personnel necessary to operate and maintain technical services, engineering and science and range and test services laboratories. Estimated amount of the contract extension is more than $6 million.

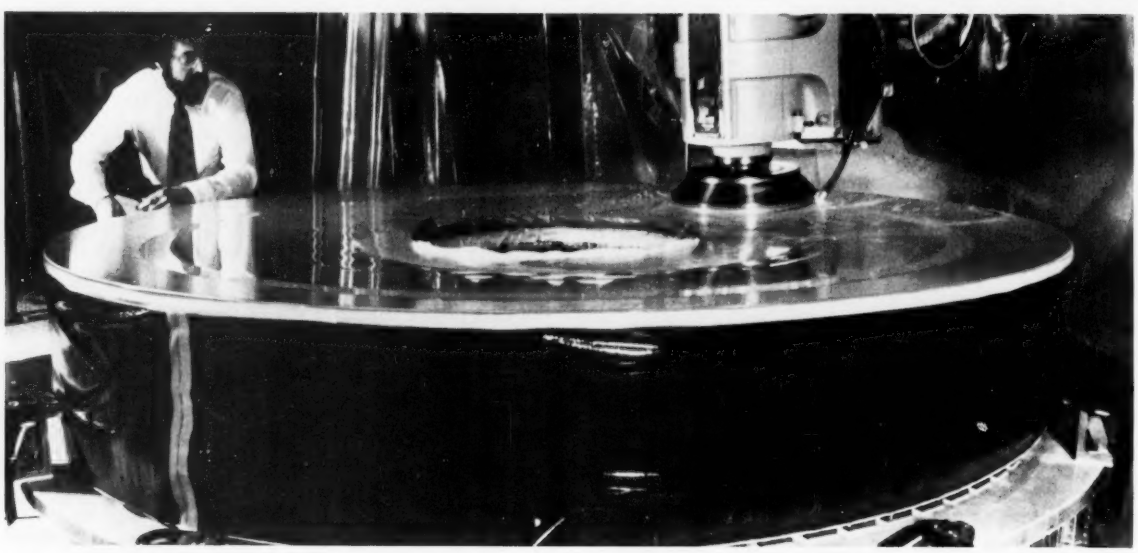
TWA Services, Inc., of Chicago, Ill., has reached a 10-year concession agreement designed to enhance facilities and services at the Kennedy center's visitor's center. TWA has been the concessionaire for the center's public tour and visitor program since 1966. Under the new agreement, TWA Services will invest up to $8.5 million in construction of new facilities.

The Klate Holt Co., of Hampton, Va., has been awarded a $1.5 million modification of its $15 million contract to provide facility and equipment maintenance support services to the Langley center. Included in the services are refrigeration and air conditioning systems, electrical and engineering services and equipment maintenance.

Rockwell International's Space Division of Downey, Calif. has signed two supplemental agreements with the Johnson center covering changes in the Space Shuttle orbiter. One supplement covers 16 engineering changes in system integration and is valued at $3.4 million. The second supplement is for work proposals previously authorized by NASA and is valued at $9.6 million.

Launches for 1979

Name	Launch Date	Vehicle	Range	Mission Remarks
SCATHA	Jan. 30	Delta	ETR	DoD R&D. Spacecraft charging at high altitude Reimbursable.
SAGE-A	Feb. 18	Scout	WFC	NASA applications satellite. Stratospheric aerosol and gas experiment.
FLTSATCOM-B	May 3	Atlas Centaur	ETR	DoD Navy communication satellite. Reimbursable.
NOAA-A	June 27	Atlas-F	WTR	NOAA weather satellite. Reimbursable.
UK-6	June 2	Scout	WFC	UK scientific satellite. Reimbursable.
Navy 20, C/U	July 20	Scout	WTR	DoD Transit, Reimbursable.
Westar-C, C/U	Aug. 9	Delta	ETR	Western Union communications satellite. Reimbursable.
HEAO-3	Sept. 20	Atlas Centaur	ETR	Third high energy astronomical observatory to study highly energetic radiation from space.
MAGSAT-A	October	Scout	WTR	NASA applications satellite to study magnetic field.
FLTSATCOM-C	December	Atlas Centaur	ETR	DoD Navy communications satellite. Reimbursable.
RCA-C	December 6	Delta	ETR	Domestic communications satellite. Reimbursable.



Grinding Glass for the Telescope—The delicate process of grinding and polishing the 2.4 meter primary mirror of NASA's Space Telescope is underway at the Perkin-Elmer Corp. in Danbury, Conn. Some 136 kg of glass will be removed during the two-year grinding operation and when finished, the mirror will weight approximately 750 kg. It is the major optical element of the Space Telescope, manufactured by Corning Glass Works, Canton, N.Y., under contract to Perkin-Elmer. The Marshall center has overall management responsibility for the Telescope, which is scheduled for launch aboard the Space Shuttle in 1983.

Patents for Inventions from NASA Research

The Office of General Counsel, NASA Headquarters, announces that the following U.S. patents have been issued by the U.S. Patent Office to NASA for inventions resulting from NASA research. Inquiries concerning them should be directed to the attention of the NASA Patent Counsel of the indicated installation.

Inventor(s) and Employer	Title	Patient No.	Installation
William H. Spuck, III, JPL	Borehole Geological Assessment	4,167,111	NRLO
Charles V. Ivie, NRLO	Multi-Channel Rotating Optical Interface for Data Transmission	4,166,959	NRLO
Shakkottai P. Parthasarathy Keshavaiyengar Y. Narasimhan, JPL	System for Detecting Substructure Microfractures and Method Therefor	4,168,483	NRLO
Kazimiera Paclorek, Ultrasystems, Inc. Irvine, Calif.	Compound Oxidized Styrylphosphine	4,168,287	MSFC
John S. Lovell United Tech., Hartford, Conn.	Portable Breathing Systm	4,168,706	MSFC
Donald A. Hess William W. Regnier Virgil L. Jacobs McDonnell Douglas Corp., St. Louis, Mo.	Passive Propellant System	4,168,718	MSFC
Frederic H. Schmitz Donald A. Boxwell C. Rande Vause Ames Research Center	Acoustically Swept Roto	4,168,939	ARC
Alvin R. Keeton, Westinghouse Elec. Corp. Trafford, Pa.	A Sodium Storage and Injection System	4,169,129	NRLO
Kenneth R. Bube, RCA, Lab. Princeton, N.J.	An Improved Solar Cell and Method of Forming the Same	4,163,678	NRLO
Stephen D. Rose Charles E. Crouch Elborn William Jones Mississippi St. Univ. Miss.	Coal-Rock Interface Detector	4,165,460	MSFC
Terry L. St. Clair, LaRC	Mixed Diamines for Lower Melting Addition Polyimide Preparation and Utilization	4,166,170	LaRC
Billy R. Ashworth, LaRC	A Seat Cushion to Provide Realistic Acceleration Cues to Aircraft Simulator/Pilots	4,164,079	LaRC

Navy Wings over Dryden—an F–14 fighter aircraft performs near the Mojave Desert facilities of the Dryden center as part of a joint NASA/Navy research program. The Navy fighter is providing in-flight assessment of a new control system concept developed by NASA to aid in the design of future high-speed aircraft. The Flight Research Center is also operating two USAF F–15 fighters and Dryden pilots have flown the YF–17, prototype of the new Navy F/A–18 multi-mission aircraft.

Another Dividend from Air and Space

Research and development in aeronautics and space have provided numerous benefits for all Americans—and at a tiny percentage of the tax dollar. Here is an example:

A Roof for the Lion House

Fans of the National Football League's Detroit Lions don't worry about game day weather. Their magnificent new Pontiac stadium has a domed, air-supported, fabric roof that admits light but protects the playing field and patrons from the elements. The 80,000-seat "Silverdome" is the world's largest fabric-covered structure, and aerospace technology played an important part in its construction.

The origin of the material dates to 1967, when NASA was looking for new fabric for Apollo astronaut space suits. It had to be durable and noncombustible, yet thin, light and flexible. Owens-Corning Fiberglas Corp., Toledo, Ohio, had been experimenting with an ultrafine glass fiber yarn called Beta yarn, which seemed to fill the bill. Under NASA contract, Owens-Corning wove the yard into a fabric, coated it with Teflon, a special fluorocarbon material manufactured by Du Pont Company, Wilmington, Del., and tailored it for astronaut wear. Later, to adapt the material to construction use, Owens-Corning thickened the yarn; Chemical Fabrics, Inc., Bennington, Vt. wove it into a stronger and more porous fabric, and applied a heavier coating of the material. The three companies have teamed with the pioneer firm in air-supported structures—Birdair Structures, Inc., Buffalo, N.Y.—to construct a variety of fabric-enclosed buildings.*

The Silverdome story illustrates why fiber glass Beta yarn to which the Teflon coating has been added suggests a bright future in the construction industry. Michigan's winter weather demanded an enclosed structure, but financing was limited and the cost of a steel-roofed stadium was prohibitive; the New Orleans Superdome, for example, cost $168 million. When architects and consulting engineers advanced the fabric dome

idea and estimated a very low $10 million roofing cost, Pontiac officials speedily adopted the plan. They budgeted $56 million for total construction costs, and incredibly, completed the stadium slightly below that figure.

* NASA does not endorse commercial products developed as a result of its Technology Utilization or Patent Licensing Programs, but it does encourage the widest possible use of its technology.

For the benefit of all . . .

NASA

National Aeronautics and Space Administration

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